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(71) Applicant: TELEFONAKTIEBOLAGET L M ERICSSON (publ) [SE/SE]; S-126 25 Stockholm (SE).

(72) Inventors: LINDHEIMER, Christofer; Köpenhamnsgatan 26, S-164 42 Kista (SE). RYDNELL, Gunnar; Magasinsvägen 4, S-430 65 Rävlanda (SE).

(74) Agent: NORIN, Klas; Ericsson Radio Systems AB, Common Patent Department, S-164 80 Stockholm (SE).

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(54) Title: METHODS AND APPARATUS FOR ALLOCATING UPLINK COMMON CONTROL CHANNELS IN WIRELESS COMMUNICATIONS SYSTEMS

(57) Abstract: A method and apparatus for scheduling uplink common control blocks in a packet data communication system, e.g., a GPRS based packet data system is described. Priority is put on allocation of uplink packet common control channels in a transmission block period immediatly after a downlink common control or broadcast channel block period. The method of allocating uplink common control blocks is beneficial, e.g., in a Compact system, where a time reuse is employed for control channels, and where base stations have periods with no transmission, coinciding with the periods when neighbor base stations are transmitting control on the same frequency. Advantageously, the method and apparatus of the present invention automatically introduce the time reuse also for uplink common control channel transmissions.

METHODS AND APPARATUS FOR ALLOCATING UPLINK COMMON CONTROL CHANNELS IN WIRELESS COMMUNICATIONS SYSTEMS

Field of the Invention

The present invention generally relates to cellular and wireless communication. More specifically, the invention relates to a method and apparatus for allocation of a Random access channel in a packet data communication system.

Background of the Invention

Recently, there has been a trend in the telecommunication community to focus more and more on wireless packet data communication rather than circuit switched voice communication. With the tremendous increase of Internet users, it is believed that the packet switched communication will soon increase more and become larger than the circuit switched voice communication that today dominates, e.g., the cellular communication. Cellular communication system manufacturers and operators are therefore looking for solutions to integrate their circuit switched services with wireless packet switched services that can provide reliable and more spectrum efficient connections for packet switched users, e.g., Internet users. This trend has made different types of packet switched communication system evolutions flourish. One of the more well known packet switched cellular systems in the telecommunications community, is the extension of the present Global System for Mobile Communication (GSM), known as General Packet Radio Service (GPRS).

GPRS is a packet switched system that uses the same physical carrier structure as the present GSM cellular communication system and is designed to coexist and provide the same coverage as GSM. The GPRS radio interface is thus based on a TDMA (Time Division Multiple Access) structured system with 200 kHz carriers divided into eight timeslots with GMSK (Gaussian Minimum

Shift Keying) modulation. The multiplexing is such that each timeslot can typically serve a number of users. One user can also be allocated more than one timeslot to increase its throughput of data over the air.

The GPRS specification includes a number of different coding schemes to be used dependent on the quality of the radio carrier. With GPRS, data rates well over 100 kbps will be possible.

There is also ongoing a development and standardization of a new air interface mode in GSM, which will affect both packet and circuit switched modes. This new air interface mode is called EDGE, Enhanced Data rates for Global Evolution. EDGE's main features are new modulation and coding schemes for both packet switched and circuit switched data communication. In addition to the Gaussian Minimum Shift Keying (GMSK) modulation, which today is used in both GPRS and GSM circuit switched mode, an 8 symbol Phase Shift Keying (8PSK) modulation is introduced. This modulation can provide users with higher bit rates than GMSK in good radio environments.

A new technique called link quality control is introduced with EDGE. Link quality control is a functionality that allows adaptation in terms of coding and modulation with respect to present signal quality. In poor radio conditions, a robust coding and GMSK modulation is selected whereas in good radio conditions, a less robust coding and 8PSK modulation is used. GPRS (and the extensions thereof) also provides a backward error correction functionality in that it can request retransmissions of erroneously received blocks (wherein one block, which is used herein to describe the smallest entity for which a retransmission can occur, is formed of four consecutive GSM frames on one timeslot). This retransmission mechanism is called ARQ (Automatic Repeat request) and is a well known mechanism in the art.

The packet data mode with EDGE modulation is called EGPRS (Enhanced GPRS) and the circuit switched data mode is called ECSD, Enhanced Circuit Switched Data. With EGPRS, bitrates over 384 kbps will be possible.

Recent development for another TDMA based cellular system, the cellular communication system compliant to the ANSI/136 standard, below referred to as TDMA/136 has been focused on a packet data system to be integrated with the TDMA/136 circuit switched mode.

This packet data system will also be based on the new EDGE technology as defined for the GPRS extension. It will then allow TDMA/136 operators to provide bit rates up to 384 kbps on 200 kHz carriers with GMSK and 8PSK modulation as defined for EGPRS.

This integration of TDMA/136 and EDGE, does not, however, come without a cost. The TDMA/136 carriers have a bandwidth of only 30 kHz, to be compared with EDGE carriers of 200 kHz. This means that operators that want to introduce EDGE, have to allocate 200 kHz for each EDGE carrier or, to put it in another way, to free up spectrum for each EDGE carrier corresponding to 7 already existing 30 kHz carriers. Since operators already today are using these 30 kHz carriers for circuit switched communications, there is a large interest that the initial deployment for EDGE in TDMA/136 systems should be made on as small a spectrum as possible.

Reuse patterns are used in cellular systems, such that one can reuse the same frequencies in different cells. Systems are usually planned such that a number of cells share a number of available channels. For example, in a 4/12 frequency reuse, there are 12 different cells that share a set of frequencies. Within these 12 cells, no frequency is used in more than one cell simultaneously. (The number 4 in "4/12" denotes the number of base station sites involved in the 12 reuse. The 4/12 denotation thus indicates that a base station site serves 3 cells.) These 12 cells then form what is referred to as a cluster. Clusters are then repeated, to provide coverage in a certain area.

Similarly in a 1/3 reuse, there are 3 different cells that share a set of frequencies. Within these 3 cells, frequency is used in more than one cell simultaneously. Thus, the higher the reuse, the better the carrier to interference

ratio for an exemplary condition. For lower reuse patterns, the carrier to interference ratio is lower, since the distance between two base stations transmitting on the same frequency is shorter. An exemplary 1/3 reuse is illustrated in Figure 1.

GPRS channels typically have different levels of robustness depending on the type of logical channel being transmitted. A logical channel is defined by its information content and is transmitted on one or several physical channels, defined by the physical channel structure; e.g., a timeslot on a certain frequency. In a packet data system, reliance on retransmission possibilities can allow a quite high error rate, which means that the reuse for user data traffic channels can be kept quite low. For example, a data traffic channel can be deployed in a 1/3 reuse whereas common control channels and broadcast channels are not robust enough to be allocated in a 1/3 reuse, since the same retransmission possibilities are not used for these types of logical channels. At least a 3/9 or even a 4/12 reuse is recommended for packet data common control and broadcast channels.

Note that a 3/9 reuse entails that at least nine 200 kHz carriers are needed (i.e., TDMA operators must provide at least 1.8 MHz of spectrum for an initial deployment). This is considered quite substantial in a TDMA system with 30 kHz carriers.

This fact has driven the TDMA community to find other solutions for initial deployment of a packet data system based on EDGE and GPRS. US Patent Application No. 09/263,950, "High Speed Data Communication System and Method", to Mazur et al, hereby incorporated by reference, teaches a method of combining TDMA/136 and the EGPRS mode of EDGE.

Briefly, the solution is to put requirements on the base station transmissions of the EDGE carriers. Base station transmissions of EDGE carriers should be time synchronised. It is then possible to allocate the control channels on different frequencies and different timeslots in different cells and thereby construct a higher reuse than what is possible by only considering frequencies. This

solution is often referred to as EDGE Compact, or Compact for short. In addition to the frequency reuse, a time reuse is introduced. For example, a certain base station transmits control signalling on a certain timeslot at a certain time and on a certain frequency, at which no other base station in the same control channel cluster (i.e., all cells where each physical channel carrying control signaling is used once and only once) is transmitting anything at all. This is repeated between a number of base stations, such that different time groups are formed. Further, to increase reliability of control channel detection in the mobile stations and base stations respectively, timeslots adjacent to each other do not both carry control channel information.

Compact provides the opportunity to introduce a higher reuse than that allowed by frequency repetition only. Thus, it will be possible to allow an initial deployment of a GPRS/EGPRS packet data system within a spectrum bandwidth much smaller than that otherwise limited by the reuse requirement for the control channels. In Figure 3A, a typical allocation for the control channels is illustrated. Therein, four different time groups are illustrated on a single frequency, i.e., a 4x time reuse is formed. In one cell, control information is transmitted in timeslot 1, (TS 1), i.e.,timegroup 1 (TG1), in certain GSM frames defined. Base stations transmitting control information on the same frequency but belonging to another time group, will not transmit at all during the frames that are used for control in base stations belonging to TG1. In another cell, control information is transmitted in TS3 (i.e., TG2), again in certain GSM frames. Base stations transmitting control information on the same frequency but belonging to another time group, will not transmit at all during the frames that are used for control in base stations belonging to time group 2. Similar reasoning applies for TS5 and TS7. Combining the time reuse with e.g., a 1/3 frequency reuse, it is possible to transmit control information in an effective 4/12 reuse using only 3 frequencies. In Figure 3A, different types of control information or logical control channels have been indicated. In block B0, broadcast information is transmitted on a

logical Broadcast Channel (BCCH) and, e.g., in block C8 logical Common Control Channels (CCCH) is transmitted (e.g., paging messages). The structure of the control channel is such that more blocks than those indicated can be allocated for broadcast or control. For example, if one more block is needed for CCCH, this can be allocated in physical block 2, on GSM frames 8-11. Allocation of 2-12 blocks is possible on a single timeslot. One broadcast information block and one common control block is always needed.

Further, to be able to find this control channel, a frequency correction burst and a synchronization burst is included in each 52 multiframe. A mobile will first search for the Frequency correction burst (located in GSM frame 25) and it will know that following this, there will be a synchronization burst 26 GSM frames later, on the same timeslot. This synchronization burst will help the mobile station to identify the base station and learn where in the multiframe structure it is.

Figure 2 illustrates an exemplary cell pattern that is formed of the reuse of time groups and frequencies combined. Note that in Compact, only the control channels have to be transmitted in the higher reuse, utilizing the time groups. The traffic channels can still be transmitted in a 1/3 reuse.

As mentioned, the transmission of control information in Compact is different than the control channel transmissions in present GSM systems. Present GSM systems have at least one carrier in each cell that transmits continuously with constant power(i.e., it transmits on all timeslots, even if there is no traffic allocated). In present GSM systems, this continuous transmission serves as a beacon in the system, for mobiles to more easily find the control channel carrier, identify the cell and, e.g., make signal strength measurements for Mobile Assisted HandOver (MAHO) algorithms.

For MAHO, mobile stations report to the network how well they can hear neighbour cells, what signal strengths they perceive. Then, based on those

measurements, more reliable handovers are possible, as mobiles move between different cells.

In the Compact system, control channel signalling is only transmitted during one timeslot in a GSM frame. Signal strength measurements should be made on the control channel transmissions rather than on traffic channels, since traffic channels can be power controlled or not transmitted with a constant power. Thus, a mobiles measurement window has to open during a timeslot when control is actually transmitted. To allow a mobile to measure on all of its neighbours in one and the same measurement position, another feature is introduced in the Compact scheme; that of timeslot rotation. During one period, e.g., a 52 multiframe, the control messages transmitted in a cell belonging to time group 1, is transmitted on TS1, timeslot 1. During the following, second period, e.g., a 52 multiframe, the control transmissions from a timegroup 1 base station is transmitted on another timeslot, (e.g., timeslot 7, TS7). Now, during this second period timeslot 1, TS1, carries control transmissions for, e.g.,timegroup 2 base stations, etc. By rotating the control timegroup allocation to different timeslots, all timegroups will eventually transmit control in one certain timeslot (one of the odd numbered timeslots) and a mobile does not need to change its position of a measurement window for signal level measurements.

The uplink allocation, allocation of resources from the mobile station to the base station, in GPRS and Enhanced GPRS schemes are such that it can either be a fixed allocation of uplink blocks, allocated to a user requesting transmission resources in the uplink, or it can be a dynamic allocation of uplink blocks. The dynamic allocation of uplink blocks are such that a downlink block indicates which user is allowed to use the following uplink block. For dynamic uplink allocation, a user must thus be able to hear the downlink transmissions, even if the data is not addressed to that user, for purposes of finding out the allocation of uplink blocks. The uplink allocation message field used is called a USF, Uplink State Flag. This message field can take a number of values, indicating to a particular one of the

mobiles allocated uplink resources on a certain timeslot that the particular mobile is allowed to use the next uplink block (or series of blocks) for transmissions.

Applicants have recognized a problem of using USF in Compact, since there are block periods in the downlink during which base stations must be silent. Returning to Figure 3A again, therein can be noted, that in a cell where TS1 is currently used for downlink control channel allocation, the base station must be silent during the same block periods in TS3, TS5 and TS7, if these timeslots are used as control timeslots in other cells. Thus, there is no possibility to transmit any USF in the downlink, indicating use of the uplink to mobile stations in that cell. This can result in lost transmission resources in the uplink, since a number of blocks may not be allocated to any uplink user at all.

Thus, there is a need for a method and apparatus that overcomes these deficiencies in the Compact systems.

Summary of the Invention

In one aspect of the present invention, a method is provided that allocates uplink common control channels in neighbor cells, in the block periods that cannot be allocated with a USF in a serving cell. This will provide a Compact system with an automatic generation of a higher reuse also in the uplink, for common control channel transmissions in the uplink direction. Briefly, the fact that a USF cannot be transmitted in one timegroup during certain periods, is advantageously benefitted from in other time groups on the same frequency by allocating the uplink blocks as random access channel blocks, or RA blocks.

During a 52 multiframe, when a base station transmits control information on TS1, it is silent during a certain number of downlink blocks on TS3, TS5 and TS7. During these periods, no USF is sent to the MSs the base station serves. Inherently, there will then be no allocated uplink transmissions in uplink blocks subsequent to the downlink blocks on the timeslots where the BS is silent.

During that same multiframe, base stations using TS3, TS5 and TS7 for control channel transmissions will, according to the invention, allocate those blocks (i.e., the blocks for which it is not possible to indicate by USF in the cell using TS1 as control channel timeslot) as random access blocks in the cells served. Advantageously, this makes the random access channel in the uplink undisturbed by transmissions of any of the other base stations transmitting control on the same frequency, but in different timeslots.

The same is true for the base stations using other time slots for downlink control. For example, the base station using TS3 for control channel transmissions is forced to be silent in the downlink for a number of block periods on TS1, TS5 and TS7. The uplink blocks subsequent to the silent downlink blocks on TS1, TS5 and TS7 in this cell will thus be unused, and can advantageously be allocated as a random access channel in the cells using TS1, TS5 and TS7 as control channel timeslots.

In another aspect of the present intention, a fixed allocation of an arbitrary number of uplink random access channel blocks is set up such that the uplink random access allocation is first made in blocks subsequent to blocks where downlink control channel allocation is made.

In another aspect of the invention, a scheduling device is described, which performs the allocation of USF and uplink and downlink blocks, such that random access channels are allocated during block periods when disturbance from other cells is low.

An exemplary method of allocating uplink blocks in a radio communications system, wherein a subset of downlink blocks available in a timeslot on a downlink frequency are allocated for downlink broadcast or downlink common control channel transmissions, and wherein uplink blocks in a corresponding timeslot on an uplink frequency can be allocated for uplink common control transmissions, includes the step of allocating at least one set of uplink blocks for uplink common control transmissions, wherein each set of uplink blocks

so allocated includes at least one uplink block and immediately follows a downlink block allocated for downlink broadcast or downlink common control channel transmissions. The uplink blocks allocated for uplink common control transmissions can be allocated, for example, for uplink random access.

Advantageously, the uplink blocks can be allocated dynamically during operation of the radio communications system. For example, each downlink block allocated for downlink broadcast or downlink common control transmissions can include an uplink state flag having a value indicating that at least one immediately following uplink block is allocated for uplink common control transmissions. Alternatively, the downlink blocks allocated for downlink broadcast or downlink common control transmissions, as well as the uplink blocks allocated for uplink common control transmissions, can be fixed during a period of operation of the radio communications system. For example, wherein a number of downlink blocks allocated for downlink broadcast or downlink common control transmissions exceeds a number of sets of uplink blocks allocated for uplink common control transmissions, each of the allocated sets of uplink blocks can be positioned immediately following one of the number of allocated downlink blocks according to a prioritized list of the number of allocated downlink blocks.

An exemplary method of allocating uplink random access transmission resources to achieve an uplink time and frequency reuse in a radio communications system, wherein portions of downlink transmission resources are allocated for downlink broadcast and downlink common control transmissions to achieve a downlink time and frequency reuse, such that downlink broadcast and downlink common control transmissions from a first base station in the communications system coincide in time with periods during which at least a second base station in the communications system is silent, includes the steps of: indicating, to a mobile station in the communications system, allocation of a portion of an uplink transmission resource for random access transmissions; and ensuring that the allocated portion of the uplink transmission resource immediately follows a

portion of a downlink transmission resource allocated for downlink broadcast or downlink common control transmissions. A transmission resource can be, for example, a timeslot in a GPRS system, and an allocated portion of a transmission resource can include one or more transmission blocks within a GPRS timeslot.

Brief Description of the Drawings

These and other features, objects and advantages of the present invention will be readily apparent to those skilled in the art when reading the following detailed description, where references are made to the appended figures in which:

Figure 1 illustrates a cellular pattern of a 1/3 frequency reuse;

Figure 2 illustrates a cellular pattern of a 1/3 frequency reuse combined with a 4x time reuse, creating an effective 4/12 time-frequency reuse;

Figure 3A illustrates a packet control channel downlink allocation pattern in a 52 multiframe structure;

Figure 3B illustrates a packet control channel uplink allocation pattern in a 52 multiframe structure;

Figure 4 illustrates how uplink allocation is indicated in GPRS/EGPRS based systems;

Figure 5 illustrates how USF is used in a Compact system in the timeslots used for control channel transmissions;

Figure 6 illustrates scheduling of silent periods in a Compact system, on timeslots used for control in non-serving cells;

Figure 7 illustrates the use of USF on a timeslot where silent periods are scheduled, according to one embodiment of the present invention;

Figure 8 illustrates a method for fixed allocation of an arbitrary number of random access blocks, according to one embodiment of the present invention; and

Figure 9 illustrates a system node scheme including an allocation and scheduling device according to one embodiment of the present invention.

Detailed Description of the Invention

The present invention will now be described, making references to a GSM cellular communication system with the alterations introduced for packet data modes of Compact cellular communication systems as described in the background. In particular, the packet data mode of GSM, GPRS and extensions thereof, are referred to. It should be noted however, that other types of cellular systems can make use of the invention, and the description is to be considered exemplary.

In a GSM communication system, physical channels on which communication can occur are divided into timeslots on a radio frequency carrier. Each carrier frequency is divided into eight timeslots, or eight physical channels. Eight consecutive timeslots form a GSM frame. The timeslots are labeled TS0-TS7, referring to both up and downlink timeslots. When appropriate, designators DL0-DL7 are used to refer specifically to downlink timeslots, and designators UL0-UL7 are used to refer specifically to uplink timeslots.

Four consecutive GSM frames form one GPRS block on each timeslot, TS0-TS7. There are different types of repetition cycles in the frame structure in GPRS and Compact. One such repetition is the 52 multiframe, containing 52 consecutive GSM frames. This is the repetition cycle for many of the control channels in GSM and Compact, e.g., broadcast channels and common control channels but also traffic channels for user data. The 52 multiframe structure is used in GSM for all timeslots where traffic channels (PDTCHs) can be allocated. In Compact GPRS/EGPRS mode, it is always used.

The 52 multiframe also includes, apart from 12 blocks (i.e., 4*12 = 48 GSM frames) for traffic or control, 2 idle GSM frames and 2 GSM frames used for Packet Timing Advance Control Channel Signalling (PTCCH), for a total of 4*12+2+2=52 GSM frames. The GSM frame structure and block allocation of logical channels is further described in ETSI TS 100 908 v.6.2.0 Digital Cellular Communication System (Phase 2+); "Multiplexing and multiple access on the

radio path" (GSM 05.02 version 6.2.0 Release 1997), hereby incorporated by reference.

Figure 1 illustrates a typical 1/3 reuse pattern. Communication between an exemplary mobile 10 and an exemplary base station 12 is possible in each cell, by allocating a frequency and a timeslot to a certain connection. The base stations can be situated in the center of a cell, in which case the antenna is transmitting in all directions. Alternatively, base station sites can serve e.g., 3 different cells, as in the figure, in which case sector antennas are used.

A 1/3 reuse is a possible reuse pattern for data traffic. However, for control information or circuit switched communication, e.g., voice, a higher reuse is necessary.

The introduction of a Compact System is based on the possibility of initial deployment of a packet data system on only three carriers. These carriers carry both data traffic and packet associated and common control signalling. A 1/3 frequency reuse pattern forms the cell structure for the EDGE carrier. The base stations are time synchronised. This makes it possible to allocate physical channels for, e.g., Packet Common Control Channels (PCCCH) and Packet Broadcast Control Channels (PBCCH) in a way to prevent simultaneous use of the same timeslots for control channels in neighbour site base stations that are using the same control channel frequency. This is illustrated in Figure 2.

In Figure 2, a frequency repetition pattern f1-f2-f3 is illustrated together with an overlaid time group pattern tl-t2-t3-t4, where each time group identifies groups of base stations using a different timeslot for control channel transmissions on the same frequency. This forms an effective 4/12 reuse for control channel transmissions. A timeslot shift or rotation can also be introduced such that the time group does not use the same timeslot continuously.

In Figure 3A is depicted an exemplary allocation of control channels for a Compact System. Base stations are allocated certain frequencies for control channels. Figure 3A illustrates, for one such frequency, that a certain number of

blocks on certain timeslots can be allocated for control channel transmission, whereas other blocks on the same timeslot can be used for traffic. There is flexibility in the number of control blocks to allocate. In Figure 3A, one broadcast information transmission is allocated in the first block, in GSM frames 0-3, and three common control channel blocks are allocated in blocks 5, 8 and 11 on GSM frames, 21-24, 34-37 and 47-50, respectively. The other periods on the timeslots used for control can be used for additional control channel blocks or packet data traffic channels.

In Figure 3A, a base station belonging to time group 1 transmits control information on TS1, physical channel timeslot 1. A base station belonging to time group 2 transmits control information on TS3 etc. Additionally, base stations in time group 1 will not transmit at all when base stations in other time groups transmit control information. This is indicated in Figure 3A by shading some of the blocks, e.g., TS3 and TS5 and TS7 in block B0 in time group 1.

In GSM frame 25, a frequency correction burst is included for each time group and in GSM frame 51 a synchronisation burst for each time group is included. These bursts enable mobiles to find the control channel and identify the current phase in the GSM frame repetition pattern.

Downlink blocks include a field in the header, intended for users that are allocated uplink resources in the cell. The message field is called USF, Uplink State Flag, and identifies the MS that can use the following blocks in the uplink. The USF value can take eight different values, 0-7, where each value can indicate a certain MS. The allocation of a certain USF value is set to an MS in an assignment message in the beginning of a packet connection setup. Whenever an MS reads its assigned USF value in a downlink block in the timeslot it was allocated to, the MS shall transmit either a single block or a sequence of four blocks on the same timeslot. The number of blocks to transmit is controlled by a USF granularity field, which today can indicate one or four consecutive blocks.

The USF field is sent in all downlink blocks. In the following descriptive example, a granularity of one block is assumed.

The USF is also used for another purpose than indicating when uplink resources are available for a certain user on the allocated timeslots. It is also used to indicate allocation of an uplink control channel denoted random access channel, RA. A USF value of 7 (coded as 111) is reserved for this. Thus, if an MS reads a USF value of (111) this shall mean USF=FREE, or, the following blocks can be used for random access. This meaning of USF=(111) denoting a RA channel on an uplink timeslot only applies on downlink timeslots that are used for common control or broadcast channel transmissions.

Figure 3B illustrates a 52 multiframe for the uplink transmissions in a Compact system. In Figure 3B is illustrated that control timeslots TS1, TS3, TS5 and TS7 can carry both traffic (T) and random access channels (R). All the timeslots that do not carry common control in the downlink are only used for traffic (T) in the uplink. It should be noted, however, that if timegroups are rotating, and sequentially utilize different timeslots as control timeslots, then, e.g., for timegroup 1, different timeslots can allow allocation of RA channels at different times, dependent on the allocation of the downlink control channels. In Figure 3B is illustrated an instant when time group 1 is using TS1 for control.

Figure 4 illustrates how allocation of uplink blocks is done in a GPRS based packet data system. An MS allocated uplink resources on a timeslot listens to the downlink on that timeslot. In the downlink blocks, the USF message field indicates which user is allowed to use the uplink. In block B0, the downlink transmits a USF1(3) value indicating that block Bl can be used by the MS allocated USF value 3. Then, the MS with the USF value 3 allocated will use block Bl in the uplink for transmissions. Following, in downlink block B1 and B2, MS with USF value 3 will continue to use the uplink during uplink blocks B2 and B3. In downlink B3, a USF value of 2 is transmitted. This means that, for uplink block B4, the MS with a USF value of 2 will transmit in the uplink. Finally, in

downlink block B4, yet another mobile station, now with USF value 4 allocated, will use uplink B5 for transmission to the base station.

Figure 5 illustrates the same thing as Figure 4, although some of the blocks are shaded. These corresponds to the blocks where control channel allocation in the downlink can occur in an exemplary situation. For example, as depicted in Figure 3B, block B0 is used for broadcast messages and block B5 is used as a common control block. These downlink blocks also carry USF values, to indicate use of the uplink to different users. In Figure 5 is shown the situation when a base station is required to be silent in a Compact scheme. Recalling what has been said about the time group reuse for Compact, where different base stations use different timeslots for its control channel transmissions to achieve a higher reuse than what would have been possible with just a frequency reuse. To achieve the effective time reuse, some blocks on timeslots where neighbor base stations transmit control must be idle. For example, if in a certain cell, control transmissions occur in TS3 at a certain instant, then, neighbor cells use TS1, TS5 and TS7 for its control transmissions. During the blocks when control is transmitted in these cells, the base station transmitting control on TS3 must be silent on TSI, TS5 and TS7, to not disturb these control transmissions. Thus, the base station with control on TS3 cannot transmit, e.g., in the downlink on TS1, and no USF is transmitted to the MSs in the cell. This is illustrated in Figure 6 where some uplink blocks cannot be allocated with the USF on these timeslots. An MS that does not hear any USF in its own cell, will assume that the uplink is not allowed to be used, and thus, the uplink will have silent periods.

According to one aspect of the present invention, the fact that neighbor cell base stations are silent in the downlink, which means that no transmissions occur in the uplink for a following block (since no USF can be read), is utilized to allocate a common control channel in these uplink blocks. Just as a 4/12 reuse is provided for downlink control channel transmissions, the uplink blocks immediately following the downlink broadcast and common control blocks can

provide a 4/12 reuse in the uplink direction. According to the invention, these uplink blocks are allocated for common control (e.g., for random access RA). As a result, the RA channel transmissions experience a higher reuse than any of the other uplink transmissions, and therefore stand a higher probability of being correctly decoded. This is illustrated in Figure 7.

In Figure 7 is illustrated a timeslot where a base station is currently transmitting control information in the downlink. In block B0, the downlink carries a broadcast control block and a USF indicating a packet random access channel, PRACH (USF=FREE). Mobile Stations served by this base station will then be able to transmit random access bursts during block Bl. Neighbor base stations are not transmitting in block B0 on timeslot 1, TS1, and thus, block Bl in the uplink will not be used. This will give whatever random access burst is transmitted in the cell served by the base transmitting control in TSl a more undisturbed environment, and a higher probability of proper decoding in the base station.

Similarly, the following downlink control block, e.g., downlink control block B5, will carry a USF indicating PRACH in uplink block B6. The same situation will occur for all the other control timeslots TS3, TS5 and TS7 and the base stations transmitting control on these timeslots at the same instant.

Apart from dynamically indicating random access bursts, e.g., Packet Random Access bursts, by use of USF, it is possible in GPRS to make a fixed allocation of a certain number of access blocks on a control timeslot. Similarly it is possible to make a fixed allocation of downlink control blocks in GPRS, by indicating where paging should not appear. This is described in ETSI TS 100 908, Digital Cellular Communication System (Phase 2+); "Multiplexing and multiple access on the radio path" (GSM 05-02) hereby incorporated by reference.

Figure 8 illustrates the rules for how the blocks are fixed allocated if a number of blocks are fixed allocated for uplink and downlink control channel transmissions, respectively, according to GSM 05.02. In Figure 8 can be noted

that if e.g., the following fixed allocation applies: 2 broadcast blocks, 4 common control blocks and 5 packet random access blocks, then the block positions used for downlink control should be: B0 (broadcast), B2, B5, B6(broadcast), B8, B11. Also, the uplink PRACH should be allocated to B0, B6, B3, B9 and B1.

The strategy for USF allocation of PRACH blocks is, according to the invention, to first allocate a PRACH following the block when there is control in the downlink, such that the higher reuse automatically is achieved. With the above example, this is achieved because DL blocks B11, preceding PRACH on UL block B0 is allocated, and DL blocks B5, B2, B8 and B0 preceding the other PRACH blocks are also allocated to the downlink for common control. Thus, with the strategy suggested in the GSM specification, the fixed allocation for the number of control blocks in the uplink and downlink will be according to the desired allocation pattern.

However, in another exemplary case, e.g., allocation of 6 PRACH blocks in the uplink and 1 broadcast block and 5 common control blocks in the downlink, the GSM specification would result in the following situation: downlink control blocks would be allocated to B0(broadcast), B2, B5, B8, Bl0 and Bl1, and uplink (PRACH) blocks would be allocated to B0, B6, B3, B9, Bl and B7.

According to the desired allocation pattern of the invention, there should be a downlink control block preceding every uplink PRACH allocation. However, note that no downlink block B6 precedes uplink block B7.

Therefore, according to one aspect of the present invention, fixed allocation of uplink PRACH blocks follows the downlink allocation of control blocks (common control and broadcast channel blocks) in a different manner than that described in connection with Figure 8. The fixed allocation of uplink common control blocks follows the downlink allocation control blocks such that whatever control block that is fixed allocated in the downlink, fixed allocation of uplink common control blocks are first prioritized such that it is preceded by a downlink control block. The uplink common control block number should be one greater

than the downlink control block number (i.e., UL # = DL # + 1). This strategy can directly be applied if the number of control blocks that are fixed allocated in the uplink and downlink are the same. It should however always be a first step in any fixed allocation of uplink common control blocks.

The above described strategies are of course also applicable if traffic in the uplink is allocated by using a fixed allocation, i.e., during which a mobile does not have to monitor any USF. Then, no blocks that neighbor cells use as random access blocks will be allocated for traffic either.

Figure 9 depicts a number of system nodes in an exemplary packet data communication system in which the above described techniques of the invention can be implemented. In other exemplary systems, additional nodes can be included, or some nodes can be omitted. In Figure 9, a mobile station MS (92) communicates with a base station BS (93). Of course, more base stations and MSs are usually present in packet data systems. The base station can be connected to a Base Station Control node, BSC (94), which in turn is connected to a Serving GPRS Support Node, SGSN (95), serving one or several BSCs. One GPRS support node is a Gateway GPRS Support Node (96) connected to e.g., other networks (not illustrated). In Figure 9, a scheduler (97) is illustrated. It is shown located in the BSC, but could alternatively be located in other network nodes as well, e.g., the base station or the SGSN. Scheduling functionality can also be split between different nodes, however, for simplicity it is located in one node in Figure 9. The sheduler (97) performs the scheduling of blocks to use for different channels.

For example, the scheduler can allocate uplink common control blocks (random access channels, e.g., PRACH) to blocks that are preceded by a downlink control block transmission according to the invention. Specifically, the scheduler can, for dynamic allocation of PRACH, assign USF values to downlink control blocks, indicating USF=FREE for the following uplink block, as described above. In addition, specifically for fixed allocation of uplink common control blocks, the

scheduler first determines which blocks are used as downlink control blocks, and then allocates random access channel blocks to blocks subsequent to the downlink control blocks.

If the number of fixed allocated control blocks in the downlink is higher than the number of control blocks in the uplink, then the uplink common control blocks to allocate can follow a prioritized list, or they can be randomly allocated among the positions preceeded by downlink control blocks.

If the number of fixed allocated control blocks in the downlink is lower than the number of fixed allocated common control blocks in the uplink, then the uplink common control blocks to allocate are first allocated to the positions preceeded by a downlink control block. Additional uplink common control block (random access block) allocation can follow a prioritized list, or uplink control blocks can be randomly allocated among the positions not preceded by downlink control blocks. In the latter case, the scheduler and scheduling algorithm assures that as many of the uplink common control blocks (random access blocks) as possible will be transmitted undisturbed from co-channel transmissions.

Although the present invention has been described with examples from a packet switched communication system compliant to the GPRS/GSM and specifically the Compact system, it will be appreciated that the solutions presented can be equally well applied to any other packet switched data communication system with the same, or similar ways of allocating uplink common control channels. The specific embodiments should therefore be considered exemplary rather than limiting the scope of the invention. The invention should rather be defined by the following claims.

Claims:

1. In a radio communications system, wherein a subset of downlink blocks available in a timeslot on a downlink frequency are allocated for downlink broadcast or downlink common control channel transmissions, and wherein uplink blocks in a corresponding timeslot on an uplink frequency can be allocated for uplink common control transmissions, a method for allocating uplink blocks, comprising the step of:

allocating at least one set of uplink blocks for uplink common control transmissions, wherein each set of uplink blocks so allocated includes at least one uplink block and immediately follows a downlink block allocated for downlink broadcast or downlink common control channel transmissions.

2. The method of claim 1, wherein uplink blocks allocated for uplink common control transmissions are allocated for uplink random access.

3. The method of claim 1, wherein downlink and uplink blocks not allocated for broadcast or common control transmissions are allocated for traffic.

4. The method of claim 1, wherein the radio communications system is a General Packet Radio Service (GPRS) system.

5. The method of claim 1, wherein uplink blocks are allocated dynamically during operation of the radio communications system.

6. The method of claim 5, wherein each downlink block allocated for downlink broadcast or downlink common control transmissions includes an uplink state flag having a value indicating that at least one immediately following uplink block is allocated for uplink common control transmissions.

7. The method of claim 1, wherein the downlink blocks allocated for downlink broadcast or downlink common control transmissions, and the uplink blocks allocated for uplink common control transmissions, are fixed during a period of operation of the radio communications system.

8. The method of claim 7, wherein a number of downlink blocks allocated for downlink broadcast or downlink common control transmissions exceeds a number of sets of uplink blocks allocated for uplink common control transmissions, and wherein each of the allocated sets of uplink blocks is positioned immediately following one of the number of allocated downlink blocks according to a prioritized list of the number of allocated downlink blocks.

9. In a radio communications system, wherein portions of downlink transmission resources are allocated for downlink broadcast and downlink common control transmissions to achieve a downlink time and frequency reuse, such that downlink broadcast and downlink common control transmissions from a first base station in the communications system coincide in time with periods during which at least a second base station in the communications system is silent, a method for allocating uplink random access transmission resources to achieve an uplink time and frequency reuse, comprising the steps of:

indicating, to a mobile station in the communications system, allocation of a portion of an uplink transmission resource for random access transmissions; and

ensuring that the allocated portion of the uplink transmission resource immediately follows a portion of a downlink transmission resource allocated for downlink broadcast or downlink common control transmissions.

10. A method according to claim 9, wherein a transmission resource is a timeslot in a General Packet Radio Service (GPRS) system, and wherein an

allocated portion of a transmission resource includes one or more transmission blocks within a GPRS timeslot.

11. The method of claim 9, wherein portions of uplink transmission resources are allocated dynamically during operation of the system.

12. The method of claim 11, wherein a portion of a downlink transmission resource allocated for downlink broadcast or downlink common control transmissions includes an uplink state flag having a value indicating that an immediately following portion of an uplink transmission resource is allocated for random access transmissions.

13. The method of claim 9, wherein the portions of downlink transmission resources allocated for downlink broadcast or downlink common control transmissions, and the portions of uplink transmission resources allocated for random access transmissions, are fixed during a period of operation of the radio communications system.

14. A radio communications system, comprising:

a base station;

at least one mobile station receiving downlink communications from the base station and transmitting uplink communications to the base station; and

a scheduler allocating downlink and uplink blocks for common control, broadcast and traffic transmissions,

wherein a subset of downlink blocks in a timeslot on a downlink frequency is allocated for downlink broadcast or downlink common control channel transmissions,

wherein the scheduler allocates at least one set of uplink blocks for uplink common control transmissions, and

wherein each set of uplink blocks so allocated includes at least one uplink block and immediately follows a downlink block allocated for downlink broadcast or downlink control channel transmissions.

15. The system of claim 14, wherein uplink blocks allocated for uplink common control transmissions are allocated for uplink random access.

16. The system of claim 14, wherein the scheduler allocates uplink blocks dynamically during operation of the radio communications system.

17. The system of claim 16, wherein each downlink block allocated for downlink broadcast or downlink common control transmissions includes an uplink state flag having a value indicating that at least one immediately following uplink block is allocated for uplink common control transmissions.

18. The system of claim 14, wherein the downlink blocks allocated for downlink broadcast or downlink common control transmissions, and the uplink blocks allocated for uplink common control transmissions, are fixed during a period of operation of the radio communications system.

19. The system of claim 18, wherein a number of downlink blocks allocated for downlink broadcast or downlink common control transmissions exceeds a number of sets of uplink blocks allocated for uplink common control transmissions, and wherein each of the allocated sets of uplink blocks is positioned immediately following one of the number of allocated downlink blocks according to a prioritized list of the number of allocated downlink blocks.

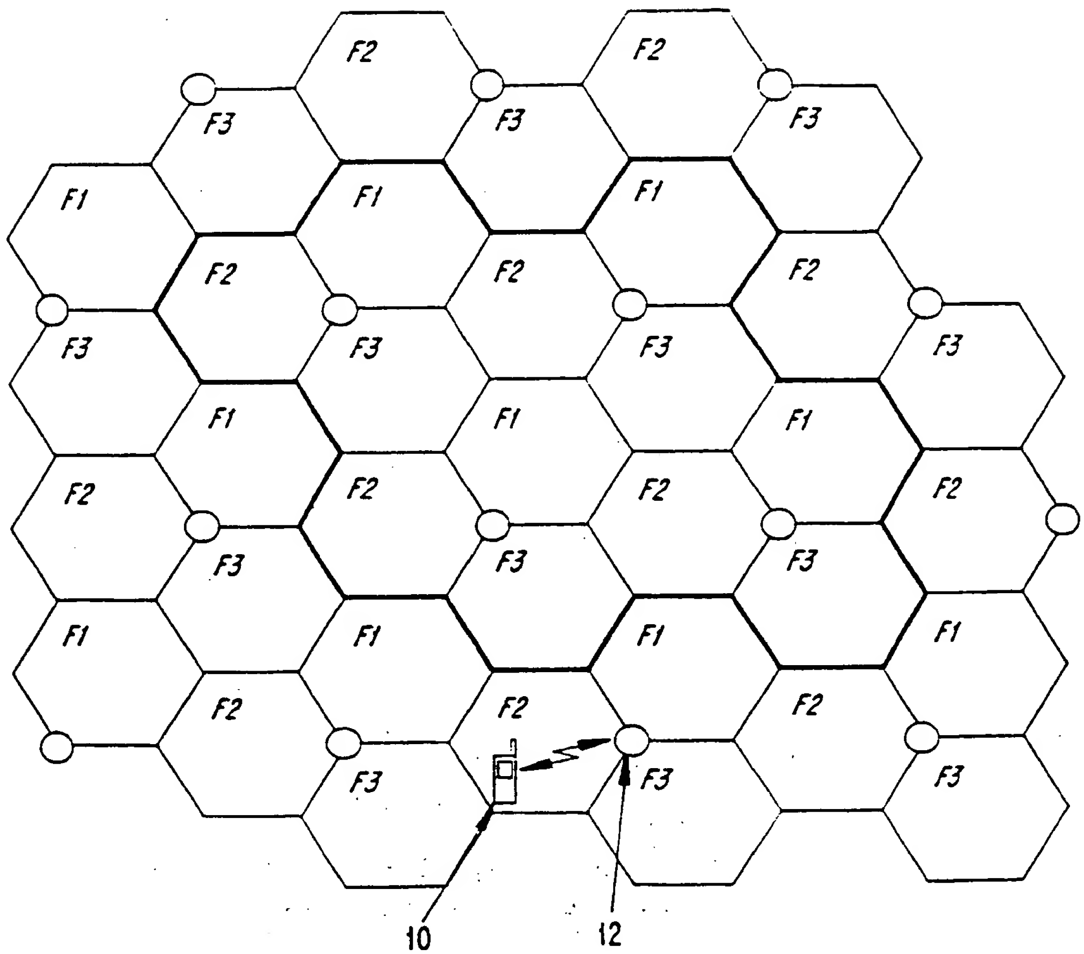
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Fig. 1

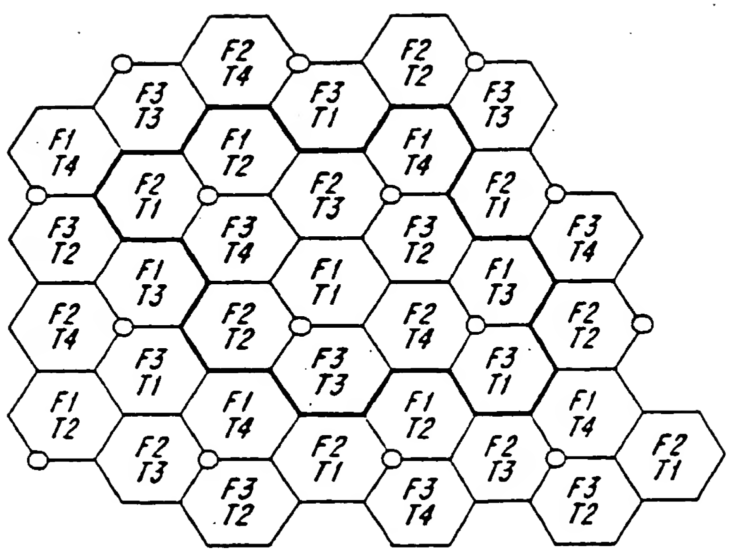
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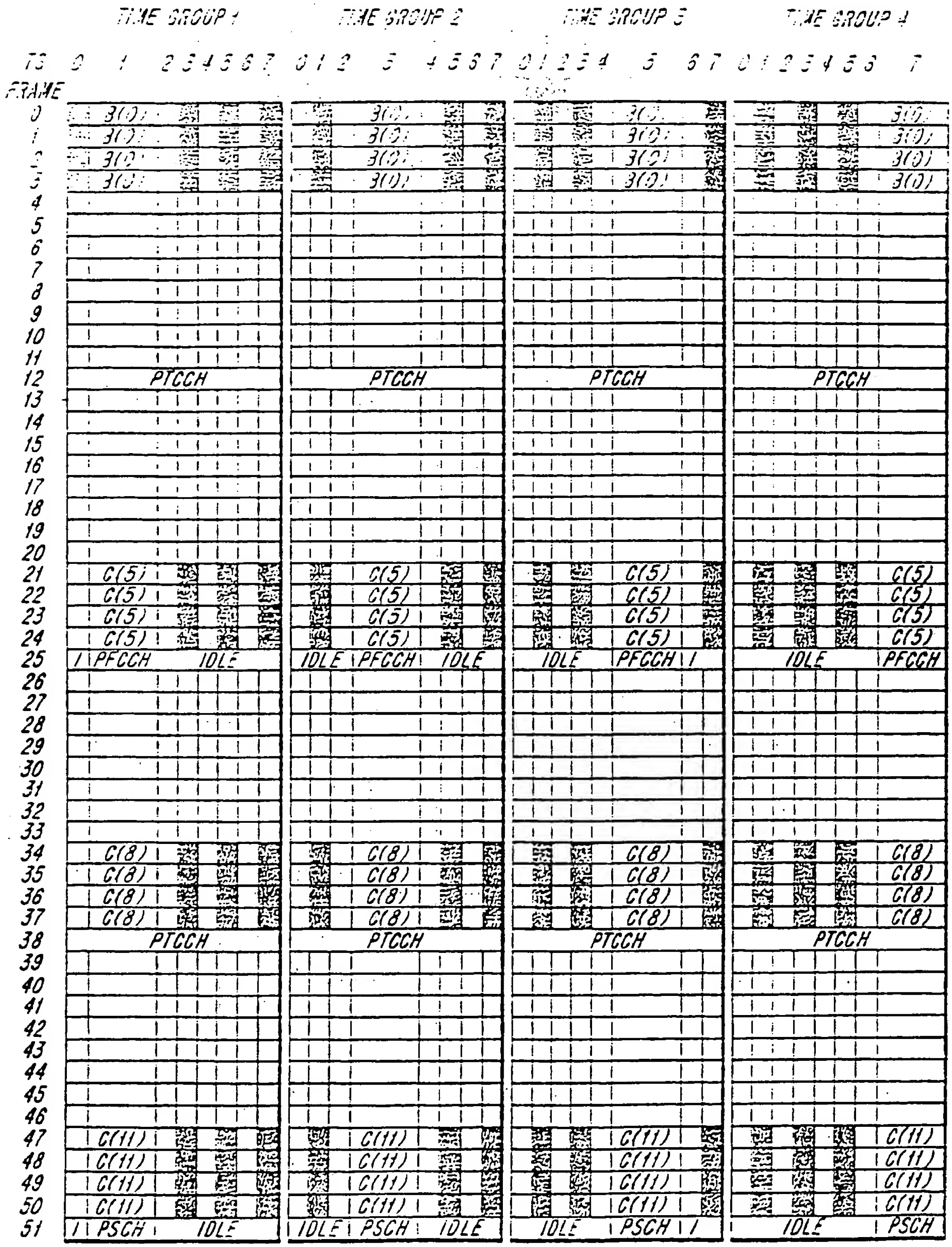
FIG. 2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TIME GROUP 2
TIME GROUP 3
TIME GROUP 4
TS
FRAME
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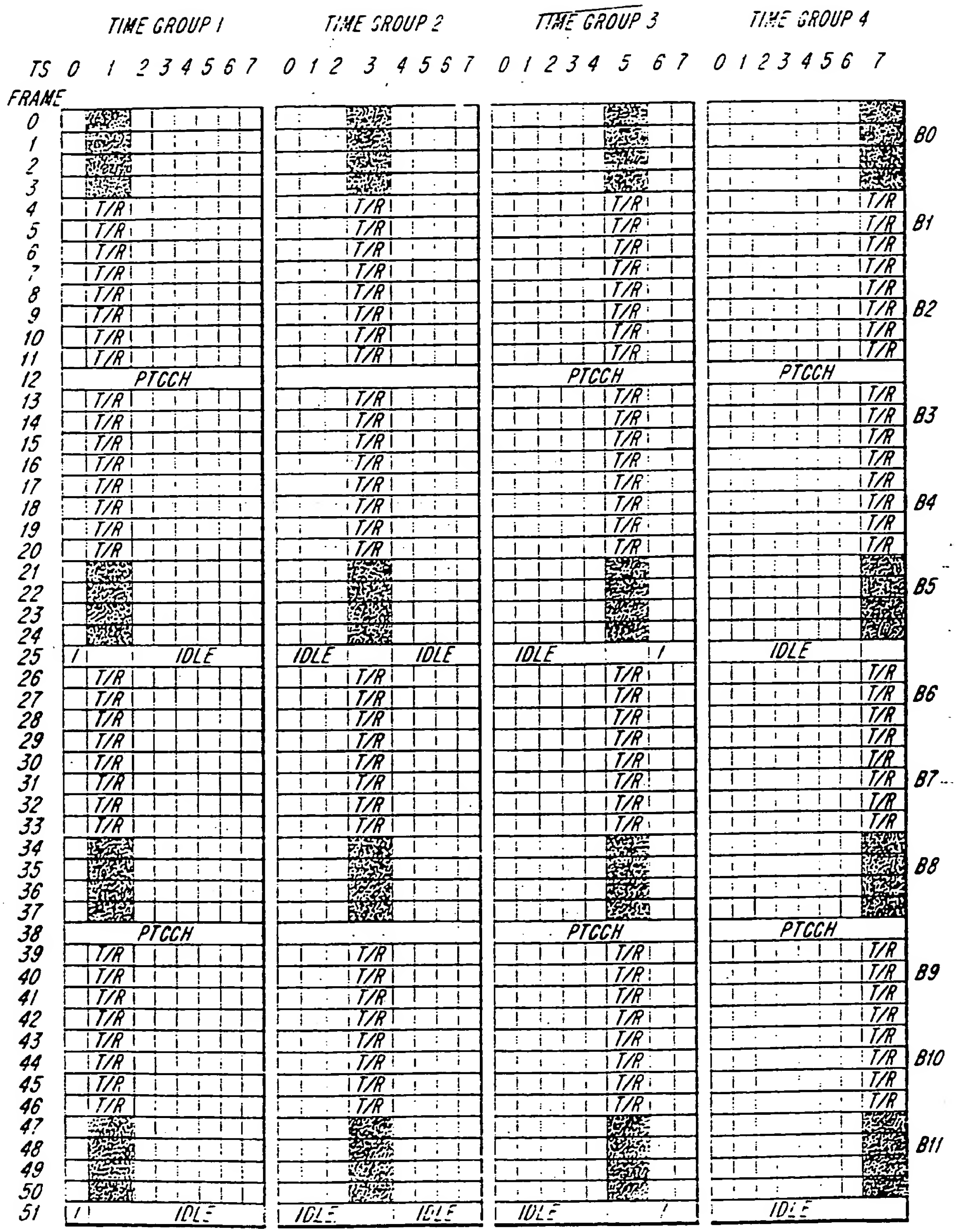
PTCCH
C(5)
PFCCH
IDLE
C(8)
C(11)
PSCH

FIG. 3A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TIME GROUP 3
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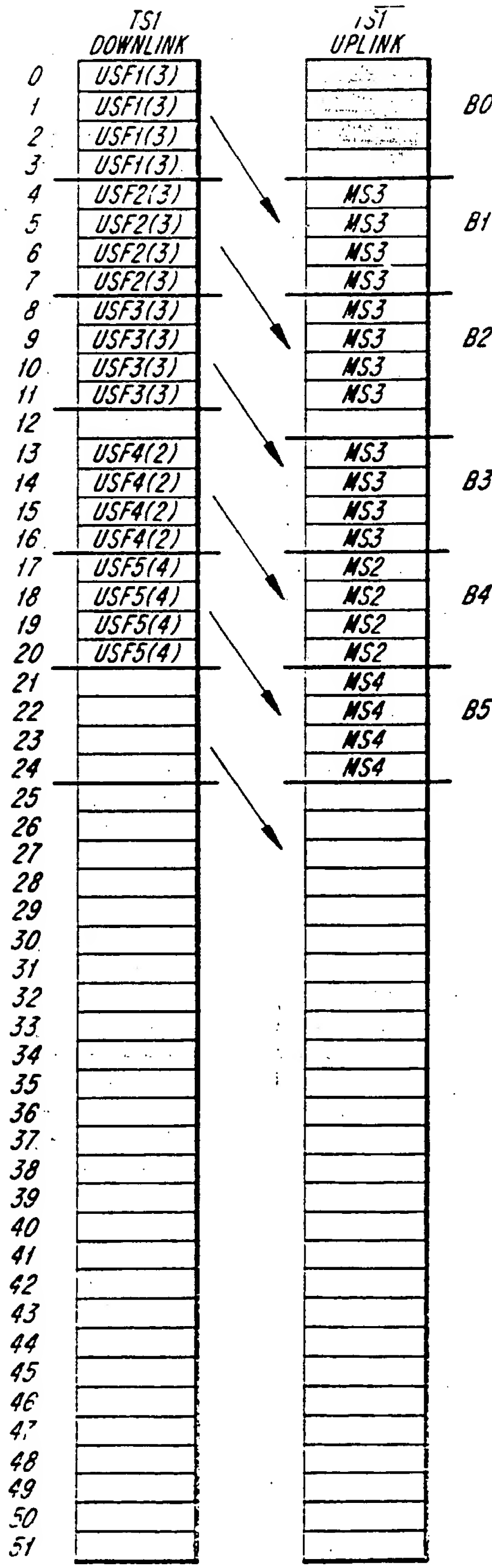
T/R
PTCCH
IDLE
B0
B1
B2
B3
B4
B5
B6
B7
B8
B9
B10
B11

FIG. 3B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B0
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B2
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B4
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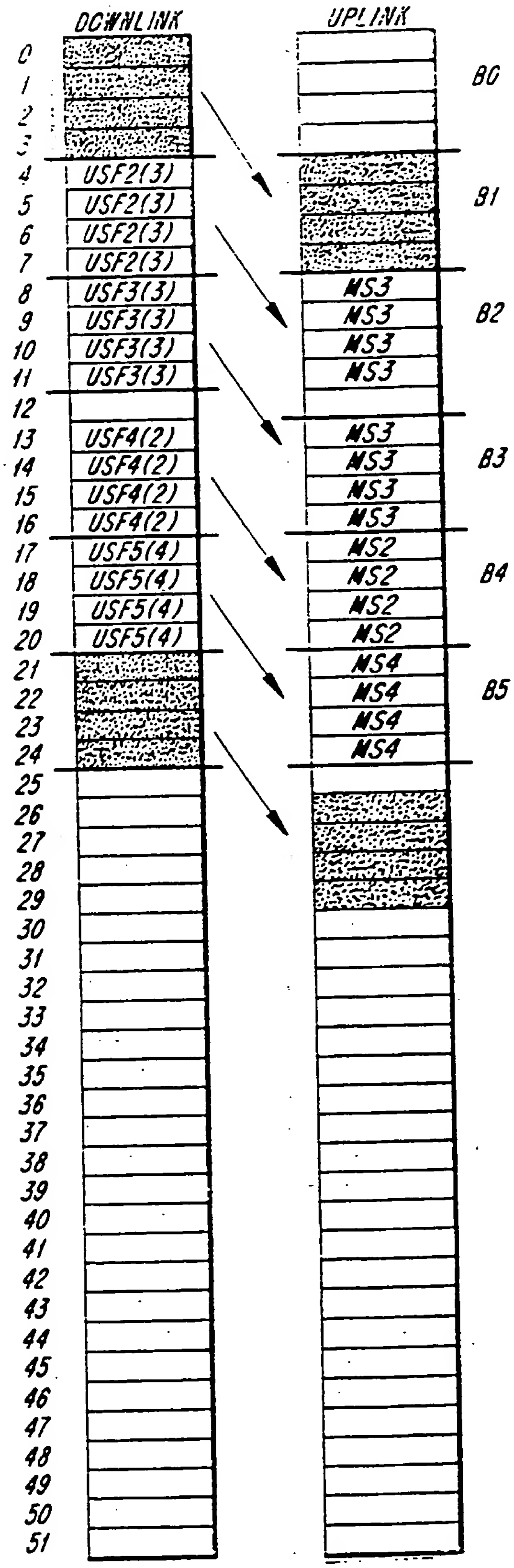
FIG. 4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MS3
MS3
MS3
MS3
B2
MS3
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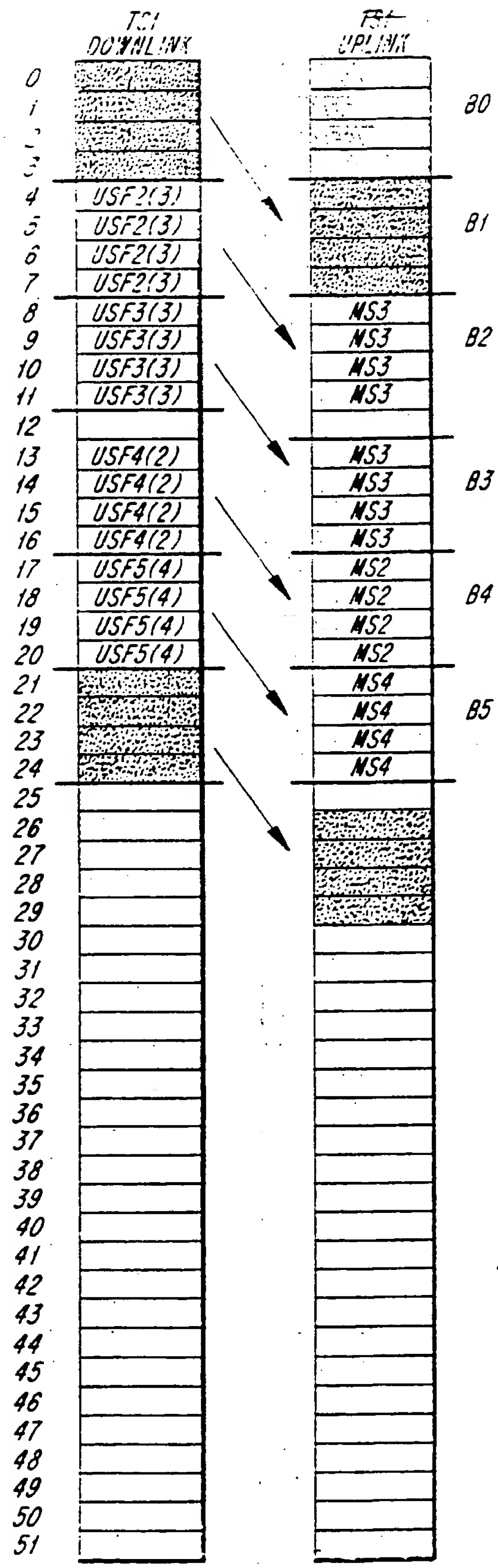
B4
MS4
MS4
MS4
MS4
B5

FIG. 5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MS3
MS3
MS3
MS3
MS3
MS3
MS3
MS3
MS2
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MS2
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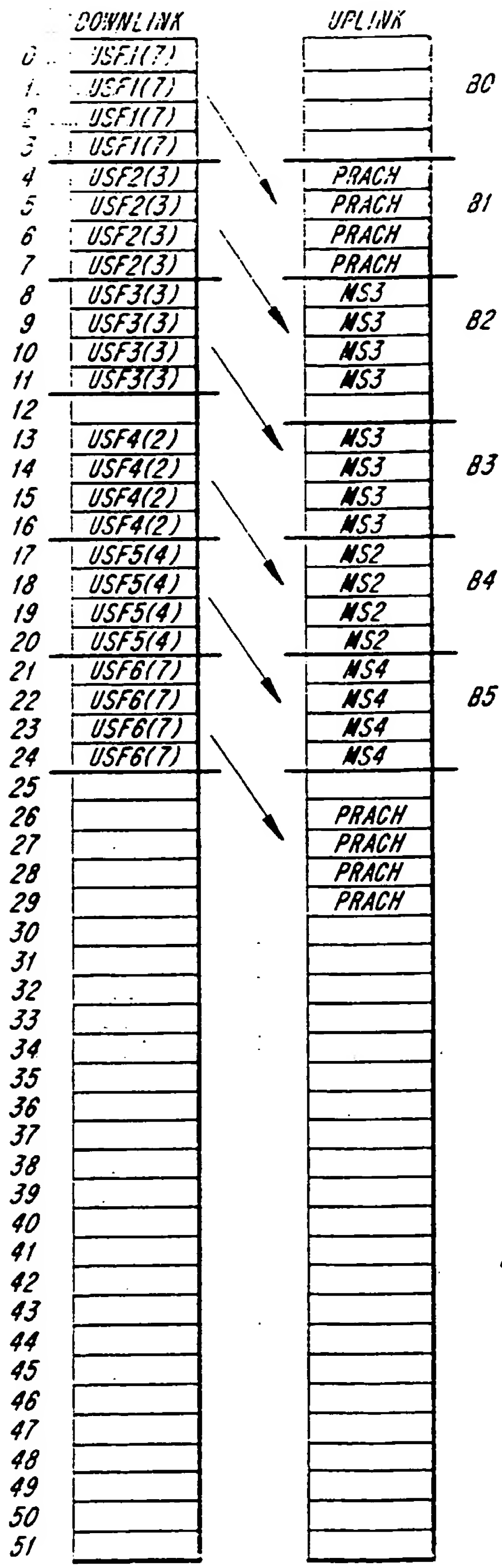
MS4
MS4
MS4
MS4
B0
B1
B2
B3
B4
B5

FIG. 6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PRACH
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MS3
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MS4
MS4
PRACH
PRACH
PRACH
PRACH
B0
B1
B2
B3
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B5
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51

FIG. 7

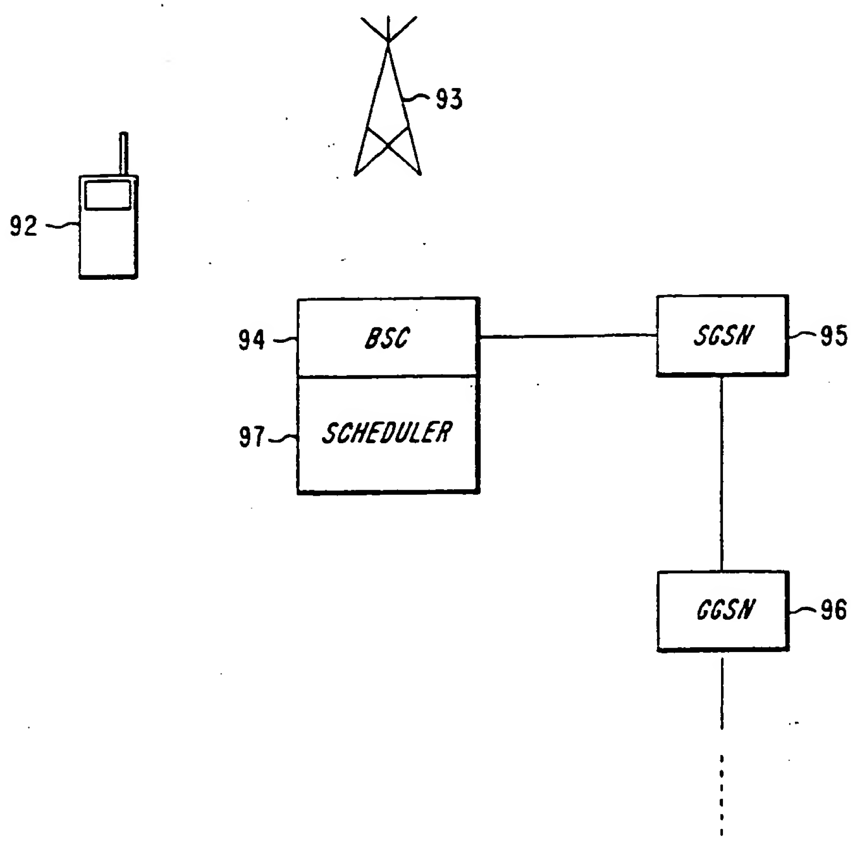
ALLOCATION ORDER FOR PRACH BLOCKS (B0, B6, ETC. INCLUDES 4 PRACH BURSTS)		B0	B6	B3	B9	B1	B7	B4	B10	B2	B8	B5	B11

ALLOCATION ORDER FOR BLOCKS WHERE PAGING SHOULD NOT APPEAR	NO. PAGING	COMMON CONTROL BLOCK ALLOCATION										
	11	B11										
	10	B5	B11									
	9	B5	B8	B11								
	8	B2	B5	B8	B11							
	7	B2	B5	B8	B10	B11						
	6	B2	B4	B5	B8	B10	B11					
	5	B2	B4	B5	B7	B8	B10	B11				
	4	B2	B4	B5	B7	B8	B9	B10	B11			
	3	B1	B2	B4	B5	B7	B8	B9	B10	B11		
	2	B1	B2	B3	B4	B5	B7	B8	B9	B10	B11	
	1	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11

ALLOCATION ORDER FOR BROADCAST BLOCKS	B0	B6	B3	B9
	B0	B6	B3	
	B0	B6		
	B0			

FIG. 8

FIG. 9



INTERNATIONAL SEARCH REPORT

Int tional Application No
PCT/SE 00/01400

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04Q7/38 H04Q7/36

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, INSPEC, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 97 12489 A (PACIFIC COMM SCIENCES INC) 3 April 1997 (1997-04-03) page 2, line 15 - line 23 page 4, line 20 -page 5, line 3 page 6, line 27 -page 7, line 2 ---	1,9,14
A	WO 98 37706 A (MOTOROLA INC) 27 August 1998 (1998-08-27) page 5, line 17 -page 7, line 24 page 10, line 8 - line 18 ---	1,9,14
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 October 2000	02/11/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Gerling, J.C.J.

1

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	PIRHONEN ET AL: "TDMA BASED PACKET DATA SYSTEM STANDARD AND DEPLOYMENT" 1999 IEEE 49TH VEHICULAR TECHNOLOGY CONFERENCE, HOUSTON, vol. 1, 16 - 20 May 1999, pages 743-747, XP002127830 piscataway (US) page 745, left-hand column, paragraph III. -page 747, right-hand column, paragraph V.	1,9,14
A	WO 99 08464 A (ERICSSON TELEFON AB L M) 18 February 1999 (1999-02-18)	

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte onal Application No
PCT/SE 00/01400

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
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			CN	1200224	A	25-11-1998
			EP	0852882	A	15-07-1998
			JP	11504779	T	27-04-1999
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WO 9837706	A	27-08-1998	AU	6177298	A	09-09-1998
			CN	1219306	A	09-06-1999
			CN	1219306	T	09-06-1999
			EP	0925693	A	30-06-1999
WO 9908464	A	18-02-1999	AU	8371798	A	01-03-1999